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DEPARTMENT OF THE INTERIOR
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BUREAU OF MINES
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SAFETY ACHIEVEMENTS OF THE CONTINENTAL MINE, CONTINENTAL-ARCHBALD COAL CO., SCRANTON, LACKAWANNA COUNTY, PA.

BY

E. H. MCCLEARY, H. A. SCHRECENGOST, ALFRED CLARKSON, AND H. R. GILL

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SAFETY ACHIEVEMENTS OF THE CONTINENTAL MINE, CONTINENTAL-ARCHBALD COAL CO., SCRANTON, LACKAWANNA COUNTY, PA.[1]

By E. H. McCleary,[2] H. A. Schrecengost,[3] Alfred Clarkson,[4] and H. R. Gill[5]

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INTRODUCTION

Much has been written and many discussions have been held concerning the prevention of accidents in coal mines, and considerable progress has been made in eliminating hazards to the health and safety of underground workmen. Although much progress has been made in the reduction of injury rates in the Pennsylvania anthracite field, the injury rates for the anthracite mines of Pennsylvania are generally higher than the average for coal mines in the United States as a whole, because the mining conditions, including the safety problems, in the Pennsylvania anthracite fields are more

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7468."

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complex than in other coal fields of the United States. Several factors contribute to this extremely difficult problem, among which are: Multiple-vein mining, steeply pitching measures, folds or faults, hard smooth floors underneath the veins, and the remining or reclaiming of pillars in severely crushed, broken ground.

In the early days of the Pennsylvania anthracite industry, only the more productive veins were mined, and this resulted in bypassing those veins that were relatively thin and those containing considerable proportions of impurities. However, the development of modern coal-preparation equipment, improved marketing conditions, and the adoption of mechanical equipment, such as the various types of conveyors and scraper loaders, have made possible the recovery of the thinner and poorer veins. Furthermore, in the early days, little or no attempt was made to recover the coal pillars, usually owing to the great amount of virgin coal available. Consequently, much of the anthracite produced within the last few years has been recovered by second and third mining - and frequently by fourth mining - in areas where operations had been suspended for many years. In such areas, the coal veins and intervening strata are usually crushed as the result of gradual subsidence, which intensifies the hazards incidental to roof control, haulage, ventilation, and mine gases.

Moreover, the use of coal-cutting equipment is not practicable in most anthracite mines because of the inclination of the veins and because, in crushed-ground areas, the faces must be advanced slowly and for short distances at a time to permit the erection of timber sets and the placing of forepoles to support the roof and sides. Thus, the slow process of mining brought about by these conditions has resulted in the production of only 0.424 ton[6] of anthracite for each man-hour worked, as compared with 0.753 ton[7] for each man-hour worked at other coal mines in the United States.

A summary contained in Bulletin 462,[8] a publication of the Federal Bureau of Mines, reveals that the rate of fatal injuries in the Pennsylvania anthracite industry was improved from 13.47 deaths per million tons produced in 1870 to 3.88 deaths per million tons mined in 1942. During the period March 16, 1942 to January 1, 1947, the fatality rate was reduced from 3.88 to 2.87 deaths for each million tons mined. On the million man-hour basis, the rate of fatal injuries was reduced from 1.643 to 1.130 and the nonfatal-injury rate was lowered from 119.01 to 83.12 during the same period.

The improvements made in both the fatal- and nonfatal-injury rates have required the cooperation of the workmen, the mining companies, and the State and Federal inspection departments. Many individual mines and companies have achieved commendable safety records which contributed greatly to the over-all average for the industry, particularly during the 1942-47 period. One of the most outstanding of these is the Continental mine of the Continental-Archbald Coal Co., a member of the Moffat Co. Interests.

6/ Adams, W. W., and Geyer, L. E., Coal-Mine Accidents in the United States, 1942: Bureau of Mines Bull. 462, 1944, 140 pp.
7/ Work cited in footnote 6.
8/ Work cited in footnote 6.

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The purpose of this circular is to make available to the anthracite industry, the bituminous-coal industry, and the general public information relating to the methods employed at this mine in the production of 1,276,381 tons of anthracite under extremely adverse mining conditions, with a man-hour exposure of 4,320,085 without a fatal injury between March 16, 1942, and August 1, 1947.

ACKNOWLEDGMENTS

Acknowledgment is given for the assistance rendered by the assistant foremen at the mine and by the members of Local Union No. 637 of the United Mine Workers of America. Special acknowledgment is given to R. Y. Moffat, president, Earl Lamb, general manager, J. S. Inglis, safety director, and P. Hughes, mine foreman, for their assistance.

GENERAL INFORMATION

The Continental mine is in the fifth Pennsylvania anthracite inspection district, of which T. D. Rees is the State inspector. It is adjacent to the southwest border of Scranton in Lackawanna County, Pa., which is in District B of the United States Bureau of Mines. Railroad service is provided by the Delaware, Lackawanna, & Western Railroad, which transports the run-of-mine coal to the company's central breaker at Taylor, Pa., for preparation.

A local office is maintained at the mine, but the principal office is at Taylor, Lackawanna County, Pa. The operating officials are as follows:

R. Y. Moffat, president
Earl Lamb, general manager
J. S. Inglis, safety director
H. R. Gill, safety engineer
Alfred Clarkson, superintendent
P. Hughes, mine foreman

The engineering work for the mine is done by the personnel of the Glen Alden Coal Co., from which the mine is leased.

The Continental mine was opened in 1860 by the Continental Coal Co. The property was acquired by the coal-mining department of the Delaware, Lackawanna, & Western Railroad Co. 5 years later. On September 1, 1921, the property was transferred to the Glen Alden Coal Co., which operated the mine until January 1, 1931. Operations were suspended from that time until June 1, 1937, at which time the property was leased to the present operator.

A fire of undetermined origin was discovered in the mine in September 1919; but the affected area is isolated by massive concrete walls, some of which extend downward through several veins. The fire seals are equipped with pipes and valves through which samples of the atmospheres behind the seals are collected at regular intervals by the safety department of the Glen Alden Coal Co. The air samples are analyzed in that company's laboratory, and the officials of the Continental-Archbald Coal Co. are informed of

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the results. Although the fire is believed to have been extinguished, workmen employed by the owning company patrol the sealed area constantly to observe any change in conditions that might affect the workmen in the Continental and the adjoining Archbald and Hyde Park mines.

No loss of life has occurred as the result of the aforementioned fire, and there is no record of other fires, floods, explosions, or other serious accidents which caused the death of more than one person.

The principal opening, through which coal is hoisted and in which men and material are handled, is a slope 1,800 feet long and inclined about 15°. An air shaft 366 feet deep to the Clark vein facilitates ventilation. In addition, the mine is interconnected with the company's adjoining Archbald and Hyde Park mines and with the Baker mine of the Glen Alden Coal Co., all of which afford emergency escapeways.

The following tabulation shows the various veins which underlie the property, their average thickness, and the interval between them:

Name of vein	Average thickness (inches)	Average interval (feet)
Diamond	102	100 (below surface)
Top Rock	36	20
Rock	36	10
Big	144	65
New County	72	25
Clark	72	50
No. 1 Dunmore .	16	60
No. 3 Dunmore .	36	85

In August 1947 the Continental mine employed 280 workmen, 257 of whom worked underground. The mine was operated two shifts a day, and the average daily production was about 1,000 tons of prepared coal. The output for 1946 was 199,408 tons. Future production depends on the accessibility of the coal in the crushed-ground areas as well as on future marketing conditions.

SURFACE-COAL HANDLING AND HOISTING

Coal is not prepared at the mine. It is transported by railroad to the company's central breaker at Taylor; therefore, the coal-handling equipment on the surface is limited to the hoist at the main slope and the car dump in the tipple.

The 6-foot cylindrical-drum hoist, which is gear-driven by a 300-horsepower, 440-volt, alternating-current motor, is in a steel building. No other machinery is in the building; therefore, the signals are plainly audible to the engineer at all times. Physical examinations are given the hoisting engineers once each year. If the hoist has been idle for an hour or longer, the engineers are required to operate the hoist through a complete hoisting cycle before persons are hoisted or lowered. The machine is equipped

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with brakes capable of stopping and holding a trip of cars at any point in the slope, and a dial-type indicator shows the position of the trip throughout the hoisting and lowering operation. Adequate flanges prevent the rope from slipping over the ends of the drum.

The hoisting rope is a 6- by 19-wire rope 1-1/8 inches in diameter and is secured with clamps after being passed through the drum and around the drum shaft. It is attached to the trip with a spelter-filled socket. A safety rope attached to the main rope at a point above the socket is used as a secondary coupling when men are being handled. Every 3 months a length is cut off the end of the rope to provide a new setting over the sheave, following which the coupling is remade at the socket.

Special man-cars, equipped with handrails and with seats designed to be in the level position when the cars are on the incline, are used for hoisting and lowering persons in the main slope. An unusual type of safety dog, developed by the mechanical department of the company, is employed to prevent runaway man-trips if the main rope or the coupling breaks. The safety dog is attached to a cross shaft underneath the car, and a flexible coupling is attached to the drawbar in such a manner that the dog is raised automatically from the roadbed when tension is applied to the main hoisting rope. Conversely, the safety dog falls quickly into the operating position the instant the tension on the rope is released; hence, protection is provided when the man-cars are lowered as well as hoisted. In addition to the secondary main coupling, side chains are used between the cars when cars are hoisted in tandem.

Signals are transmitted electrically, using 12-volt alternating current, to a bell in the engine room, and return signals are given by the engineer through a 12-volt circuit to electric horns at the various slope levels before persons are permitted to board the man-cars. The signaling devices at the slope levels are so located that, in case of necessity, they can be operated by persons aboard the cars; nevertheless, the company rules require an attendant to be on duty when persons are being hoisted or lowered. The code of signals in use has been employed for several years and has proved effective in minimizing the inadvertent movement of cars. Notices containing the code of hoisting signals are posted in the engine room and at the various slope levels. A telephone system provides an auxiliary method of signaling in the slope.

The hoisting equipment, including the hoist and its appurtenances, the sheave, the ropes and couplings, the rope rollers and deflecting sheaves, and the safety dogs, is inspected each day by the engineers and slope attendants, and records of the examinations are kept. These records are scrutinized carefully by the superintendent at least once each week and by the safety engineer each time he visits the mine.

SURFACE BUILDINGS

The surface buildings consist of the steel engine house previously described, a wash house and a lamp house of concrete blocks, a repair shop

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constructed of concrete, and the mine office and a car-repair shop of wooden construction. These buildings are well-maintained under supervision of the outside foreman, who makes periodic inspections to determine whether or not a health or safety hazard exists. If such a hazard is found, the condition is corrected promptly.

The wash house is provided with an adequate supply of hot and cold water, hanging baskets for the workmen's clothing, and sanitary toilet facilities. The floor is washed and antiseptic powder applied daily. The building is heated with steam radiators that are guarded to prevent persons from contacting them. Two exits from the building are available, and cold-air drafts are prevented by weather doors.

The standard charging equipment used in the lamp house is protected by fuses in the charging circuits, and shock hazards are minimized by rubber mats on the floor. Fuel for the flame safety lamps is piped to a safety-filler spigot from a storage tank outside the building. The flame safety lamps are cleaned, filled, and properly assembled after each period of use.

The shops are kept clean and orderly, and the moving parts of machinery are guarded adequately. Goggles are used by the repairmen when chipping, grinding, or doing other work that may cause eye injuries. The machine parts and supplies kept at the mine are stored neatly on racks in the shops; however, few such parts and supplies are kept at the mine because these materials are readily available at the distributor's supply houses nearby.

GENERAL SURFACE CONDITIONS

As in the surface buildings, good housekeeping is practiced throughout the plant yard. Mine supplies, such as rails, pipes, boards, and timbers, are stored neatly according to kind and size at safe distances from mine openings and surface buildings. The paths, roads, and walkways are kept free of obstructions and are illuminated at night.

Carbon dioxide-type fire extinguishers, which are inspected and weighed every 6 months to determine their contents, are kept at suitable places in the tipple, wash house, lamp house, fan house, mine office, and repair shops. Three water hydrants of a standard type used by the city of Scranton are centrally located in the plant yard and are connected to city water mains. Furthermore, the services of the Scranton fire department are readily available.

METHODS OF MINING AND TIMBERING

During the years since the Continental mine was opened and before it was acquired by the present operating company, first mining was completed in the Diamond, Top Rock, Rock, Big, New County, and Clark veins. Exploratory work by the present company has shown that mining in the No. 1 Dunmore vein would be unprofitable; consequently, development work is confined to the No. 3 Dunmore vein. Mining in this vein is done by the chamber-and-pillar method, and the places are driven on sights according to an engineering plan developed by the Glen Alden Coal Co.

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A study of the mine maps indicates that, in the early development of the veins overlying the No. 1 Dunmore, the places were driven on the contour of the strike; thus, columnization of pillars is not possible in the development work now being done. Little thought was given to pillar extraction during the early development of the upper veins; the apparent plan was to leave the pillars intact. Because of the sloughing of pillars, the decay and destruction of timber supports, and the gradual subsidence resulting from vertical and lateral pressures, the veins and other strata have been crushed severely. Most of the original openings have become blocked tightly with solidly packed crushed coal and roof rock intermingled with silt and other small particles carried in the mine water and in the drainage from the surface.

Because the demand for anthracite has increased greatly during recent years and the minable coal reserves have decreased, the first-mined areas of former years were reopened to recover the remaining pillars; therefore, a large percentage of the production now obtained is from second and third mining. Because of these conditions, no definite plan of mining can be followed, which necessitates driving counter gangways and exploratory openings at right angles to and crossing the original pillars between chambers. When a set of pillars is found that can be mined in a practical and economical manner, they are recovered by driving skips along them from both sides of the counter gangway. The skips are driven along the outby sides of the pillars, after which the remaining portions are recovered by the pocket-and-stump method. Thus, because of the crushed-ground conditions, each counter gangway or other opening must be advanced slowly and for extremely short distances to permit placing massive timber sets to support the loose material overhead and along the sides. Under these conditions, adequate safety for the workmen can be provided only by driving pointed forepoles behind the legs and over the collars of timber sets or in advance of the working faces.

To establish ventilation and provide emergency escapeways, two such counters or similar exploratory openings are advanced, usually abreast and about 300 feet apart. Under normal conditions, the intake air entering one counter passes through the loosely packed caved material in the original chambers to the parallel counter, which serves as the return airway. The adequacy of the air currents is carefully observed by the officials; and, when the caved material is too tightly packed to permit the passage of an adequate volume of air, cross counters are driven to connect the parallel openings.

The recovery of each set of pillars in the reopened areas presents an individual problem, but the general plan is to mine each level successively from the upper to the lower veins. This, to a great extent, restricts the development of the No. 3 Dunmore vein. In the No. 3 Dunmore, belt conveyors are used for main transportation, chain conveyors for secondary transportation to the belts, and shaker conveyors in the working places. The use of coal-cutting machines in this vein is impracticable because of the undulating nature of the vein and because it is desirable to mine the area slowly to maintain adequate support for the workings in the upper levels. The gangways and accompanying airways are driven about 25 feet wide on 55-foot centers to

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predetermined distances, and the chambers are driven in accordance with a retreat method of mining. Crosscuts driven through the pillars in both the gangways and chambers maintain the ventilating currents near enough to the faces to permit control of the air in working places by means of line brattices. Pillars are not recovered in this work at present owing to the necessity for retaining support for the overlying working areas. Pneumatic drills are employed at the faces, and the coal is blasted off the solid and loaded onto the conveyors by hand.

The roof conditions immediately over the separate coal veins are variable, as each vein is accompanied by some change in the rock structure. These conditions are further affected by the crushed condition of the adjacent strata. In the No. 3 Dunmore vein, where first mining is now being done, the immediate roof is laminated bone and rock, which averages 8 inches in thickness, and the main roof is massive sandstone. The floors beneath the veins are hard, smooth rock.

Systematic timbering regulations established by the company and enforced by the officials provide for permanent props or timber sets to be kept not more than 6 feet apart and not more than 6 feet from the faces. These regulations are the minimum requirements, and additional props or timber sets are placed where conditions are believed to require them. Temporary props placed inby the last permanent roof supports are used for safety in places where the roof is relatively firm, and forepoles are driven on the sides and overhead in places where the strata are crushed. The props and timber supports are hitched securely into the floor, and adequate cap pieces are used on the tops of the props. Adequate timber supplies are kept near the working places and other points of use.

The personnel is well-trained in the vibration method of roof testing; they make such tests frequently during the shift, and miners are required to test the roof thoroughly upon the entrance of an official or inspector. Blunt-end steel bars are used as testing tools. The condition of the roof in working places, as well as along the gangways, airways, and travelingways, is observed carefully by the officials, and corrective measures are taken when required. Breakline props or cogs are used at the fracture line along the ends of pillars.

Three-piece wooden timber sets are used along the roadways, and workmen are constantly engaged in reinforcing heavily laden timbers and replacing timbers that have been broken or become decayed. In addition to the regular tests and observations by the officials, a full-time roof inspector is employed who daily travels the roadways to scale down loose roof material and to examine the condition of the timbering.

EXPLOSIVES, DETONATORS, AND BLASTING

The explosives, in the original unopened 25-pound containers, and original unopened cardboard packing cases of 25 detonators each are issued to the workmen from the explosives- and detonator-storage magazines, respectively. Explosives and detonators are carried by separate persons to the main slope,

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where they are placed in a special explosives-delivery car to be lowered into the mine. A 4-inch wooden partition separates the explosives and detonators in the car, which is built of 2-inch lumber. The car is fully insulated, and an insulated coupling is used to attach the car to the hoisting rope. The explosives car is lowered separately in the slope, and the workmen, who receive their explosives and detonators at the various slope levels, carry them to their working places in the upper veins. In the No. 3 Dunmore vein, the workmen carry the explosives and detonators to the main belt conveyor, where they are then placed in a specially constructed box for transportation on the belt to points near the working places. The special container used on the belt is made of 2-inch lumber and contains a compartment separated by a 4-inch wooden partition for the detonators. Adequate clearance is provided between the roof and the top of the container. No person is permitted to carry explosives and detonators at the same time. Boxes made of 2-inch lumber and having 4-inch wooden partitions are provided for the safekeeping of explosives and detonators in the working places.

Permissible explosives are used for all blasting underground, and the charges are detonated with instantaneous and delay electric detonators, using magneto-type firing units. Individual firing lines, supported on props by wooden cleats, are installed in each place. Both wires of the firing lines are broken and kept short-circuited at safe distances from the faces and at the firing terminals when not in use. The firing stations are kept at least 30 feet apart.

Certified miners charge and fire the blast holes promptly after preparing them. The primer cartridges are assembled at the faces as needed, and the leg wires of the detonators are kept short-circuited until ready to connect them to the firing lines. Wooden bars are used for tamping the stemming. Men in adjacent places are given personal warning, and shouted warnings are called out before firing. Warning signs are posted when necessary to prevent persons from approaching an area where blasting is being done.

Each miner or person in charge of a party is provided with a permissible flame safety lamp and makes tests for gas before and after firing the shots. The workmen are instructed to refrain from firing shots if the presence of gas is indicated by the flame of a safety lamp, and examinations for gas are made after firing and before persons, other than the miner, approach the face.

The workmen are instructed to remain away from the faces long enough to allow the smoke and fumes to be diluted and carried away after the shots are fired. Waiting periods of 15 minutes for instantaneous detonators and 30 minutes for delay detonators have been established as safe intervals before anyone returns to the face if a shot misfires. In such instances the firing lines are disconnected from the firing unit, the ends at the battery and the "safety breaks" are shunted, and a careful examination of the wires is made. If the shot fails to fire in a second attempt, the fact is reported to an official who examines the misfire and supervises its removal. Such charges are removed by firing a second hole drilled at least 2 feet away from and parallel to the misfired charge.

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VENTILATION AND MINE GASES

A centrifugal-type main fan, installed in a brick-concrete building, induces air flow in the mine. The fan is at a separate air shaft remote from other openings; thus, the return air cannot be drawn into the intake airways. The fan, which is offset about 18 feet from the side of the shaft opening, is in a steel casing, and the air duct connecting the fan casing and the air shaft is of steel; the surrounding surface area is free of dry grass, brush, and other fire hazards. The fan is operated continuously on the exhausting principle, and it is equipped with a recording pressure gage and an audible stop-signal device adjacent to the superintendent's office. The fan is inspected daily by the colliery electrician. Hand-operated switches are provided in the power circuits entering the mine, and the electrician is instructed to cut off the mine power if a fan stops. Special "runners" have been designated underground whose duty it is to warn and withdraw the workmen in case of fan failure. If a fan fails, the men are not permitted to reenter the mine until it has been examined and reported to be in a safe condition.

The total volume of intake air cannot be determined because of the numerous openings and fractures through the strata to the surface, but the fan has a capacity of about 250,000 cubic feet of air a minute when operated against a pressure of 2.5 inches water gage. The ventilating current is divided into several splits; and, where possible, the volumes passing through the last crosscuts or most distant inby points exceed 6,000 cubic feet a minute.

In the crushed-ground areas, the circulation of this volume of air in the separate splits is impracticable, and in most splits it is impossible to attain because of large losses through the fractures between veins and to the surface. However, company regulations require that perceptible air currents be maintained in each working place and that such currents be of sufficient volume to dilute and carry off flammable and harmful gases. To maintain compliance with this regulation, each official employs smoke- or dust-dispersal methods to determine the perceptibility of the air currents in those places where the areas are too large to permit practical use of an anemometer. Permissible-type flame safety lamps are used by the officials and miners in charge of parties for routine testing of the air, and if the air current is not perceptible in a place or if the sufficiency or quality of the air is questionable, work in the place is stopped until sufficient ventilation has been restored.

Usually, the intake air currents are conducted along the haulage roads to the working places from where they are broadcast through old workings to the main return-air courses leading to the fan. However, where it is necessary to conduct the return air from one gangway along the haulage road in another, the air is tested with sufficient frequency to determine its quality. In the No. 3 Dunmore vein, where first mining is being done, the return air is not permitted to travel through haulageways.

Crosscuts and cross counters are driven at intervals close enough to assure adequate ventilation; in the No. 3 Dunmore vein these intervals do

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not exceed 60 feet. The crosscuts between chambers are closed with wooden stoppings, and concrete-block stoppings are used between intake and return airways.

Where doors are required in the ventilating system, they are erected in pairs to form air locks, and a sufficient volume of air is permitted to pass through them to assure adequate ventilation. Such doors are self-closing, hinged to open against the ventilating current, and attended when the mine is in operation.

Wooden and cloth line brattices are used where needed to maintain positive circulation of the air at the working faces.

The mine is classed "gassy" by the Federal Bureau of Mines, and enough certified assistant foremen are employed to examine every place before the men begin work and to make at least two visits to every working place during the shift. In addition to tests for gas during these inspections, each miner or person in charge of a party is required to test for gas at frequent intervals during the shift. Workmen are instructed to cease work in any place where the tests indicate a hazardous condition and to report the condition without delay to their immediate supervisor. Daily reports regarding the condition of the various sections are made by the assistant foremen. These reports are kept at an accessible place on the surface, and they are read carefully by the superintendent at least once each week and by the safety engineer each time he visits the mine.

CONTROL OF DUST

The mine is generally damp, and little difficulty has been experienced in maintaining relatively dust-free atmospheres. The principal source of dust is drilling; however, the workmen use respirators when drilling, and auger-type rotating pneumatic drills are used.

HAULAGE

Coal is not transported on the surface other than in railroad cars which are loaded underneath the tipple. Brake sticks and railroad-type pinch bars are provided for the use of those handling railroad cars, and these persons are also provided with safety belts and use protective headgear. The employees are not required to cross over the railroad tracks.

Haulage between the loading points of the various conveyors and the slope levels is done by cable-reel locomotives, which are kept in good repair and equipped with good headlights, good brakes, and alarm gongs. Lifting jacks and rerailers are provided as part of the equipment on every locomotive. Rubber mats are provided on the floors and seats to minimize the hazard of shock to the operators, and all exposed wiring about the locomotives is encased in rubber hose. The original bumpers of the locomotives, found to be too high for safe operation, have been replaced with lower bumpers equipped with guards to prevent cars from being forced into the cabs if an accident occurs.

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The haulage roads are kept in good alinement, are ballasted with broken mine rock, and are well-drained. Splice bars are used at every rail joint, and the condition of the tracks is observed carefully by the officials who cause repairs to be made immediately when defective joints, defective frogs or switches, or broken rails are found. The main haulage tracks are of 40-pound steel rails and the secondary tracks of 30-pound steel rails, both of which are attached firmly to wooden ties spaced at about 18-inch intervals.

The point-type track switches are well-installed and equipped with bridle bars and switch throws placed on the clearance side of the tracks. Stumbling hazards are minimized by placing the bridle bars and connecting rods in channels below the level of the floor. Safety blocks in the switch openings minimize the hazard of persons catching their feet in them. Electric lights illuminate the track switches.

Adequate clearance is provided along the roadways for persons to travel with safety, and the roadbeds and walkways are kept free of spilled coal and other obstructions. The crosscuts and chamber openings, which are marked with signs, are utilized as holes for shelter. Shelter holes, kept free of obstructions, are also provided at the various slope levels.

None but authorized persons are permitted to operate or ride upon the haulage equipment, and the practice of jumping on and off the moving equipment is prohibited, as are coupling cars in motion, making flying switches, "nipping," and backpoling. Slides are used when necessary for descending grades, and the motormen are required to keep their trips under control at all times. Permissible trip lights are used on the rear of all trips hauled and on the front ends of trips pushed by the locomotives. Block-signal systems are used where two or more locomotives are operated independently on the same track.

Special car blocks are used under the wheels of cars left standing on sidetracks or along the roadways, and clamp-type car stops are attached to the rails in working places. Swinging headblocks and derailing switches protect persons working in places driven to the dip, and drags are used on the rear of trips ascending grades. Special trucks are used for hauling rails and timbers, and at least two mine cars are placed between the locomotive and the trucks carrying long objects.

ELECTRICITY

Electric power (4,000-volt alternating current) is transmitted to the Continental mine from lines of the Glen Alden Coal Co.; this power is stepped down through two transformer stations to 440 and 110 volts for operation of the main hoist, the main fan, and the tipple equipment, and for surface lighting. A third transformer station reduces the primary voltage to 206 volts for application to a synchronous converter. Each transformer station is enclosed by a woven-wire fence with a gate that is kept locked. Lightning arresters are provided in the primary circuits, and the casings of the transformers are grounded. "Danger - High Voltage" signs are displayed on the station fences.

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The 206-volt alternating current is converted to 275-volt direct current by a rotary converter installed in a concrete-block building, the door of which is kept locked. The switchboard is comprised of slate panels mounted on a grounded steel frame, and the entrances are guarded. The controls are readily accessible for emergency shut down. An oil-break switch is in the primary circuit, and an automatic circuit breaker is in the direct-current circuit. Rubber mats are on the floor in front of the switchboard and around the converter, and insulating platforms are placed in front of the control apparatus of other surface electric equipment.

The 275-volt direct-current circuit enters the mine through a borehole, the casing of which is grounded, and is connected to the trolley circuit underground.

The trolley wires are supported adequately by insulated hangers spaced at intervals of 20 feet or less to prevent sagging. The wires are kept in good alinement about 10 inches outside the track; and where possible to obtain height, they are kept about 7 feet above the rails. Sectionalizing switches at each branch circuit and at intervals of not more than 1,500 feet along the roadways are marked by electric lights. The trolley wires are not extended beyond the last crosscuts in gangways or into poorly ventilated areas, and the terminals are anchored with strain insulators. Protection boards are installed along the wires on each side of all doors and at crossings where the wires are less than 6-1/2 feet above the rails.

The haulage tracks are made electrically continuous by bonds at each rail joint and with cross-bonds at intervals of about 150 feet. In the gangway extensions and other places where the locomotives are operated beyond the trolley-wire terminals, one side of the track is bonded.

The stationary electric equipment underground consists of several pumps installed in temporary locations and the conveyor-driving units, all of which are so installed as to minimize fire hazards. A supply of dry sand is kept at each installation. The circuit of each electric machine is protected by fuses or by other overload devices; and the frames of motors, the metallic enclosures of switches, and other equipment that might become charged by insulation failure, are grounded.

Telephones, in good operating condition, are installed at suitable places to provide a means of communication between the various sections of the mine and the surface. The telephone lines are adequately supported by insulators on the sides of the roadways opposite the power conductors, and the circuit is protected by a lightning arrester at the point where it enters the mine.

The only electric apparatus used near the face areas are cable-reel locomotives which are run into a few places.

The trailing cables of the cable-reel locomotives are of the single-conductor type, but one side of the temporary track is bonded in those few places where locomotives are operated. These cables are protected by fuses

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at their terminals. When splices are made in the cables, they are made mechanically strong by the use of clamping rings, then insulated with rubber tape and covered with friction tape. Each splice made during the working shift must be reported to the colliery electrician, who examines the work at the end of the shift to determine its mechanical and electrical efficiency.

SAFEGUARDING MECHANICAL EQUIPMENT

Close supervision is maintained over the guarding of moving machine parts, both in the mine and on the surface. Guardrails are erected around the rotary converter, belts, and pulleys; gears are protected; and enclosures are fitted over the ends of projecting shafts. Adequate clear spaces are provided around machinery, the areas are kept free of stumbling hazards, and good illumination is provided. Persons are not permitted to oil machinery while it is in motion, and any person who removes a guard to make an emergency repair or for other reasons must replace the guard before starting the machine.

Each miner is required to have a full complement of tools in his working place, and tool boxes are provided for each party of workmen. The combined length of any ax and its handle must not exceed 18 inches, according to company rules. The tools are regularly examined by the officials, and any faulty tool observed is sent to the shop immediately.

UNDERGROUND FIRE PREVENTION

Lubricating oils and greases are not stored in the mine; they are taken underground each day in metal containers in the approximate amounts required for the day's work.

Underground structures, such as foremen's quarters and first-aid rooms, are built of incombustible materials.

Carbon dioxide-type fire extinguishers are kept in the foremen's quarters, dry sand is kept at each stationary electrical installation, and the compressed-air pipe lines can be converted to carry water. Boards, fibrous plaster, concrete blocks, and rolls of brattice cloth are stored at readily accessible places.

MISCELLANEOUS

The mine maps are kept up to date by semi-annual surveys made by the engineering department of the Glen Alden Coal Co., and mining is not permitted in any area unless approved by that department. The maps contain essential information required for the safe operation of the mine, including the inclination of the coal veins, the excavated areas, the previously mentioned fire area and its seals, the boundary lines, and the location of sumps, dams, and impounded water. The maps kept in the mine office also show the direction of the ventilating currents in colored arrows, and the location of electric equipment is also indicated.

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One or more emergency ways of escape, in addition to the main roadways, are available to workmen in every section of the mine, and escape to the surface may be made through any or all of the three shafts at the adjoining mines. The escapeways are kept in good condition and are indicated clearly by direction signs in the mine. Each of the various openings giving access to the mine is constantly under the observation of watchmen and employees.

Personal identification of each underground workman is possible by means of numbered checks attached to the permissible electric cap lamps. Each person is assigned a specific numbered lamp which he uses daily, and if a lamp exchange is required during the shift, the number of the replacement lamp is recorded in the lamp house where the daily record of persons underground is kept.

The underground workmen wear protective headgear, and most of them wear safety-toe footwear and use goggles when doing work hazardous to the eyes. A program of educating the workmen in the use of safety apparel has been instituted recently, and the number of employees using goggles and wearing protective footwear was increased from 60 to about 75 percent in the period June 1 - July 31, 1947. The number of eye and toe injuries decreased materially during that period.

GENERAL SAFETY CONDITIONS

Enough State-certified officials are employed to insure two or more visits to every working place during the shift. These officials examine any idle or abandoned section of the mine before workmen are allowed to enter such places, and the date and the initials of the examining official are marked in the working or other places examined. The air courses and travelways are examined daily, and air measurements are made in the last crosscuts and in the returns of the several air splits each week. Records of these examinations and air measurements are kept.

A full-time safety engineer is employed, whose duty is to try to provide for the safety and protect the health of the employees of the Moffat Co. Interests, of which the Continental-Archbald Coal Co. is a part. Frequent inspections are made by the safety engineer, who has authority to oversee the correction of any hazard he observes, and reports of his inspections are made to R. Y. Moffat, president of the company.

An excellent spirit of cooperation exists between the safety engineer and the mine officials, as well as between all the operating officials on the one hand and the State and Federal inspection departments on the other. The Tentative Coal-Mine Inspection Standards for Anthracite Mines, issued by the Federal Bureau of Mines, is employed by the safety engineer in making his inspections, and it is of interest that of the 428 separate standards listed in the aforementioned publication that are applicable to this mine, 412 or 96 percent are fully complied with and 6 are complied with in part, according to the reports on 6 separate inspections made by Federal coal-mine inspectors.

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The grievance committee representing the local union of the United Mine Workers of America serves as a safety committee and meets jointly with the officials to discuss mine safety. A joint safety meeting comprised of workmen and an official is held in each section each Monday, or the first workday following an extended period of idleness. At these meetings the workmen are informed of the circumstances surrounding each accident that occurred during the preceding week, if any, and recommendations are made with a view to preventing recurrences. The suggestions of the workmen are welcomed by the officials in charge of these meetings. A sound spirit of cooperation exists between the officials and the workmen in matters pertaining to safety.

About 90 percent of the workmen received first-aid training in 1942. First-aid training was again attempted in 1943; but owing to the shortage of manpower and war-time commitments, it was discontinued. A well-equipped first-aid room is maintained on the surface, and others are maintained at convenient places in the mine. General hospital facilities are available in Scranton, about 2 miles from the mine, and an ambulance is kept ready in a heated garage.

DISCUSSION OF ACCIDENTS

Each serious accident, whether or not personal injury is involved, is investigated carefully by the safety engineer, the mine superintendent, and the mine foreman. A complete record of these investigations is kept; and they show the cause of the accident, the number of persons injured, the seriousness of the injury, and the days lost due to the injury. Responsibility is placed whenever it is possible to do so. These records are summarized monthly, and each foreman is kept informed of the comparative standing of his section.

Specific data relative to accidents at the Continental mine are available and have been since March 16, 1942, when the full-time safety engineer was employed and began to compile such information. Table 1 summarizes the accident-experience record of the Continental mine as compared with the average for the Pennsylvania anthracite industry.

A complete comparison of the accident rates in anthracite mines with those of other coal mines of the United States cannot be made unless consideration is given to the comparative rates of production. It is noted from the table that the average rate of production in the anthracite industry was 0.397 ton per man-hour, including recovery from strippings, spoil banks, and dredging operations, during the period 1942-46, inclusive. During the period March 16, 1942 to January 1, 1947, the average rate of production at the Continental mine was 0.305 ton per man-hour; the cause of the low production per man-hour is attributed chiefly to the severe crushed-ground conditions under which the coal was recovered. Moreover, this calculation is based on underground mining exclusively.

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TABLE 1. - Accident data, anthracite industry

Year	Tons mined	Man-hours worked	Lost-time injuries		Accident-frequency rates				Ton per man-hour
					Per million man-hours		Per million tons mined		
			Fatal	Non-fatal	Fatal	Non-fatal	Fatal	Non-fatal	
1942	58,316,022	137,559,994	226	16,371	1.643	119.010	3.88	280.73	0.424
1943	59,505,666	150,832,008	226	15,268	1.498	101.225	3.80	256.58	.395
1944	63,591,628	163,549,087	174	12,438	1.060	76.050	2.74	195.59	.389
1945 1/	54,673,567	143,000,000	143	11,600	1.000	81.120	2.62	212.17	.383
1946 1/	60,282,000	154,000,000	174	12,800	1.130	83.120	2.89	212.34	.391
5-year average..	59,273,781	149,788,218	188.6	13,695	1.266	92.105	3.186	231.48	.397
Continental slope mine									
March 16, 1942	199,067	693,573	0	66	0	93.703	0	331.55	0.287
1943	281,198	932,222	0	65	0	69.725	0	231.15	.302
1944	242,888	804,207	0	61	0	75.849	0	255.67	.302
1945	169,216	585,299	0	35	0	59.798	0	206.83	.289
1946	199,408	602,953	0	41	0	67.998	0	205.61	.331
5-year average	218,335	723,651	0	53.6	0	73.415	0	244.16	.274
August 1, 1947	106,436	388,535	0	24	0	61.770	0	225.49	.305

1/ Preliminary information.

Further analysis of table 1 shows that, during the 5-year period, 1942-46, an average of 1.266 fatal injuries and 92.105 nonfatal injuries occurred in the anthracite industry for each million man-hours worked. On the million-ton basis the average rate of fatal injuries was 3.186, and that of nonfatal injuries was 231.48 for each million tons of anthracite produced.

During the comparative period March 16, 1942 to January 1, 1947, the rate of injuries at the Continental mine was consistently lower than the over-all average of the industry. During that period no fatal injury occurred, and the average rate of nonfatal injuries was 73.415 on the million man-hour basis. However, on the million-ton basis, the average rate at the Continental mine was 244.16 or 12.68 greater than the average for the industry as a whole. The reason for this is the severe crushed-ground conditions at the Continental mine, which required a comparatively greater amount of time to produce a given amount of coal, the average rates of production being 0.397 ton per man-hour for the industry and 0.305 ton per man-hour for the Continental mine.

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CONCLUSIONS

The reduction of accident-frequency rates in anthracite mines requires the cooperation of the officials, the workmen, and the State and Federal inspection departments. The maintenance of a better-than-average safety record at the Continental mine demonstrates the value of such cooperation, the benefits to be derived from the employment of a full-time safety engineer, and the desirability and value of compliance with the safety standards established by the Federal Bureau of Mines.

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